Design of a Controlled Dosing Scheme for Liquids using a Venturi

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Introduction:

Key challenge: Controlled and sustained dosing of small quantity of one liquid into another, continuously, without a dosing pump

Solution: Venturi based dosing mechanism

Principle of dosing:

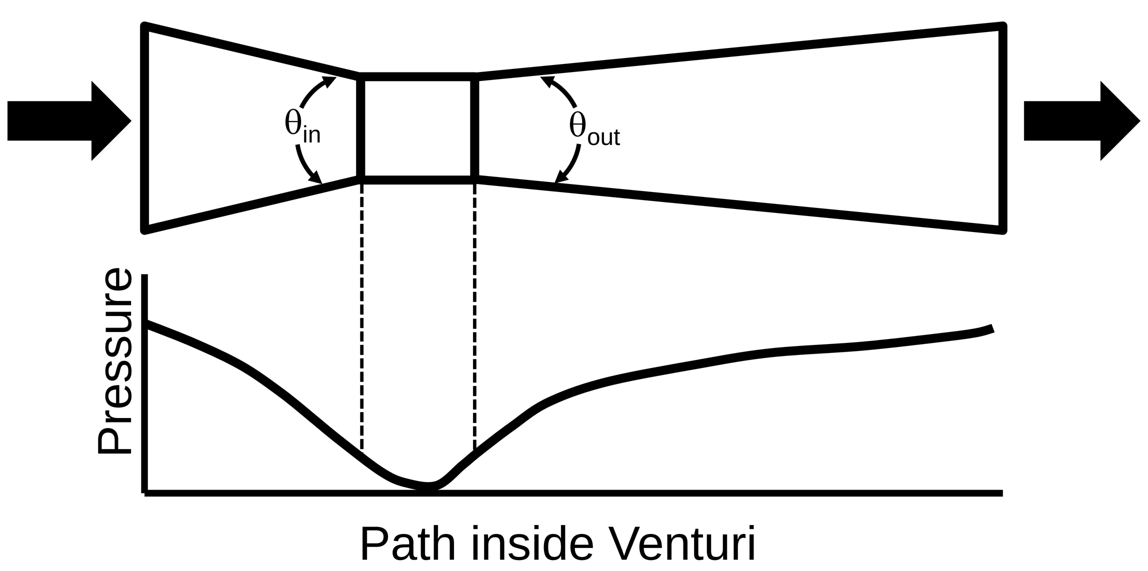

Figure 1. Pressure drop inside a Venturi

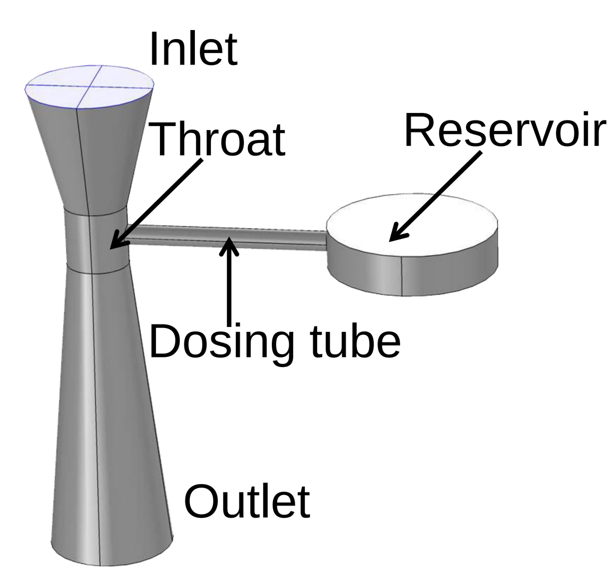

Figure 2. A typical design of venturi dosing system

Key focus: Effect of venturi dimensions, flow rate through venturi and physical/rheological properties of reservoir liquid on dosage.

Methods:

Assumptions: (1) No-slip boundary
(2) Steady state laminar flow condition

Navier-Stokes equation:

$$\rho(u\cdot\nabla)u = \nabla\cdot\left[-pI + \mu\left(\nabla u + (\nabla u)^T\right) - \frac{2}{3}\mu(\nabla\cdot u)I\right] + F \qquad \nabla\cdot(\rho u) = 0$$

Solved using COMSOL Multiphysics 4.2a, CFD module

Results:

$$\beta = \frac{D_{throat}}{D_{inlet}}$$

(1) Dimensions of Venturi

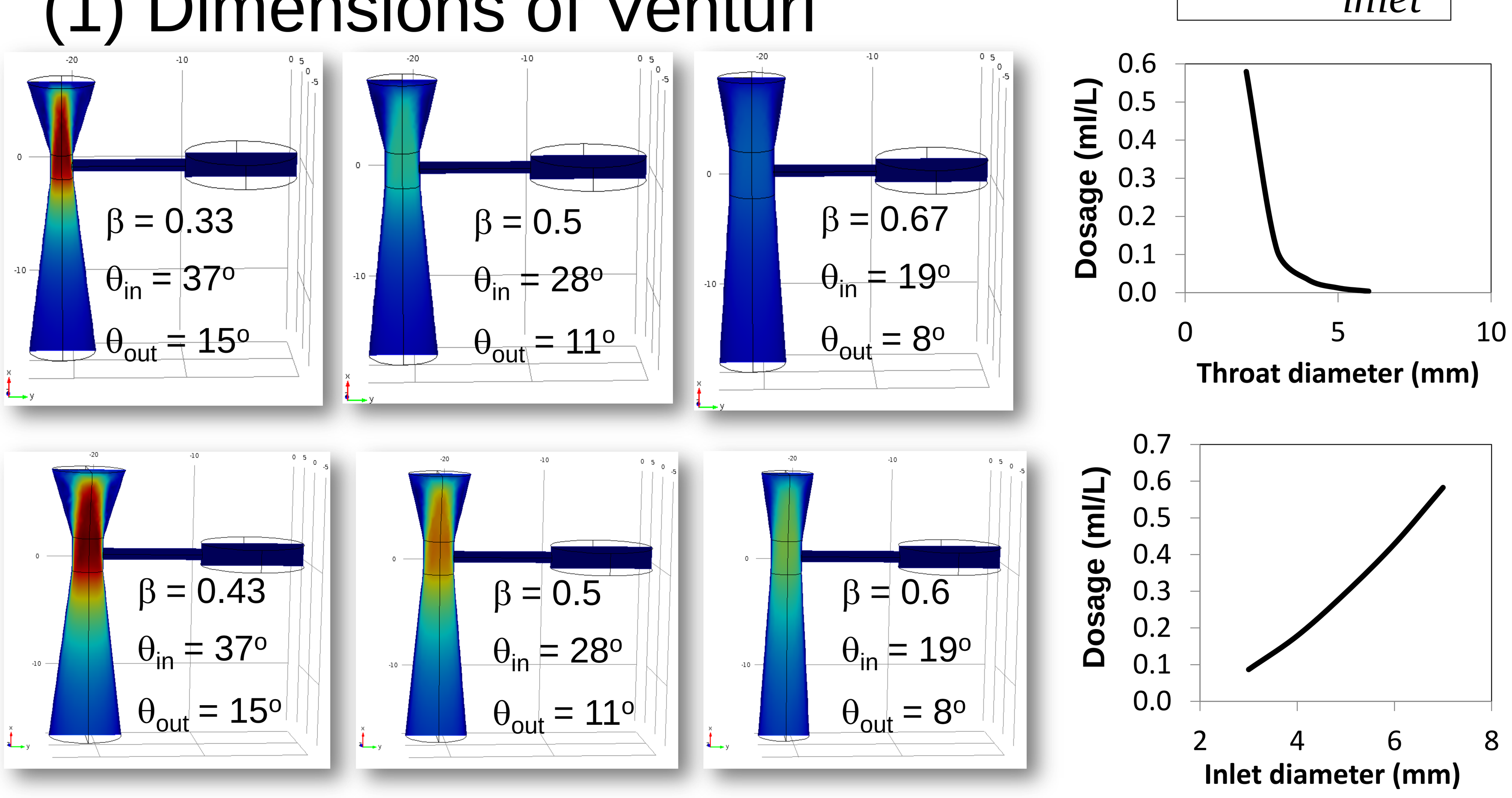

Figure 3. Effect of cone angle on velocity profiles within a venturi and the dosage at various – (a) Throat diameters, (b) Inlet diameters

cone angle ↑ pressure drop ↑ dosage ↑

(2) Dosing tube

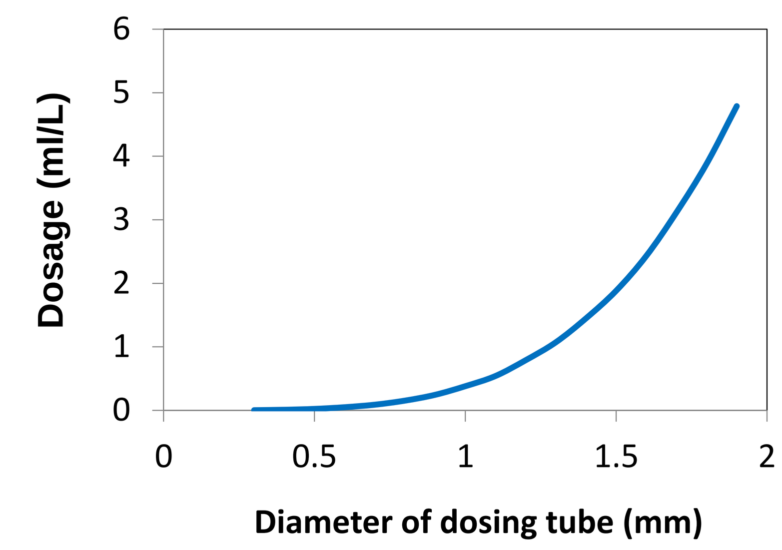

Figure 4. Effect of dosing tube diameter on dosage

(3) Flow through venturi

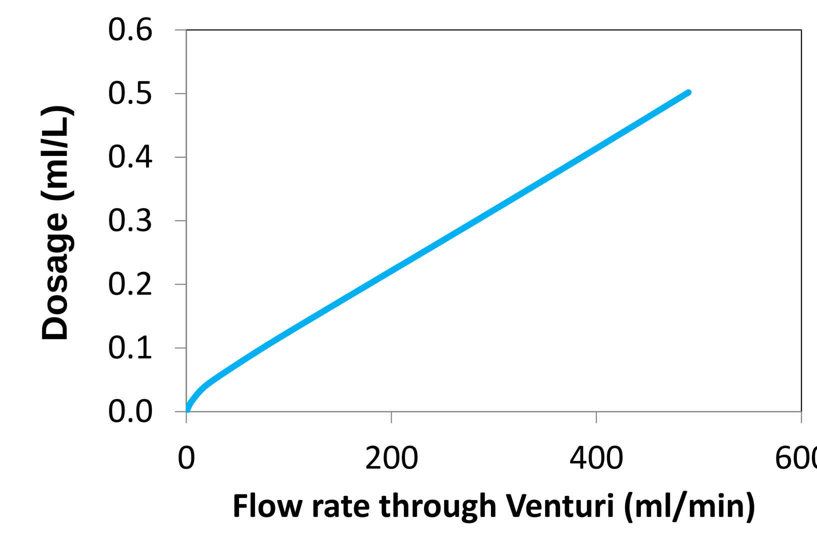

Figure 5. Effect of flow rate through venturi on dosage

(4) Rheology of reservoir liquid

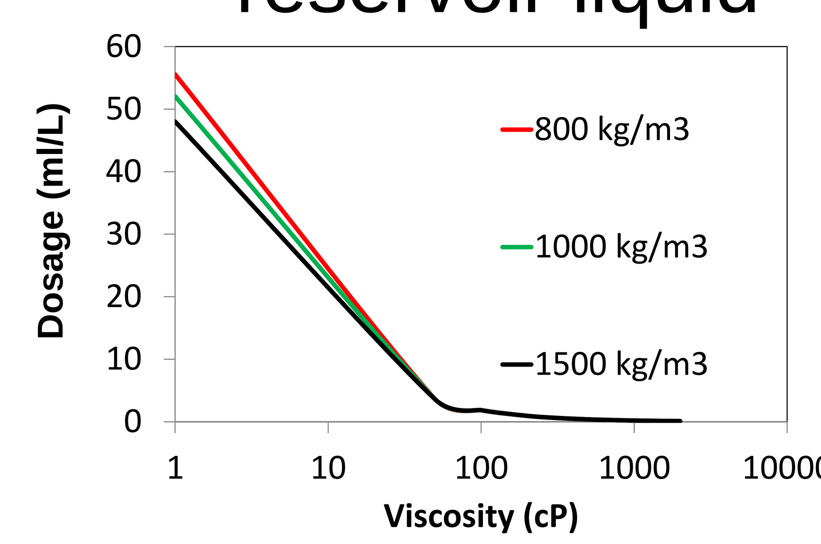

Figure 6. Effect of viscosity of reservoir liquid on dosage (at various densities)

(5) Model validation

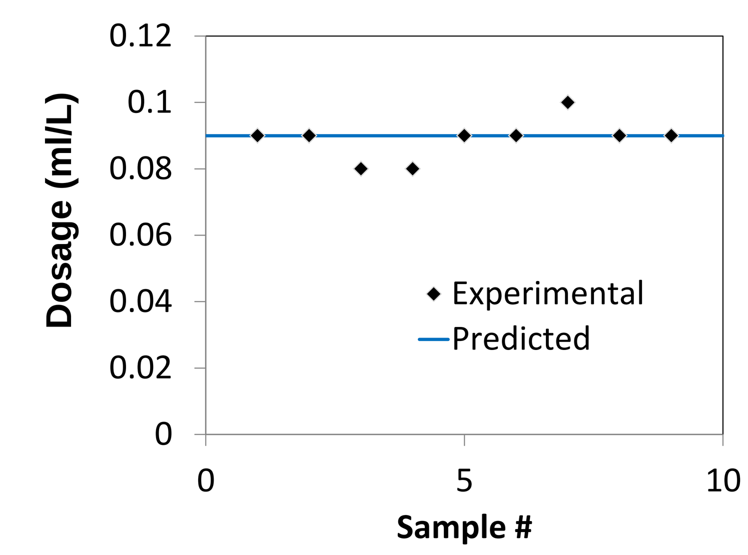

Figure 7. Validation of predictions with experimental observations

(6) Summary

Parameter		Effect on Dosage	
Cone angle (Throat diameter↓)	↑	Non-linear	↑
Cone Angle (Inlet diameter↑)	↑	Linear	↑
Flow through Venturi	↑	Linear	↑
Dosing tube diameter	↑	Non-linear	↑
Viscosity of reservoir liquid	↑	Non-linear	↓

Conclusions:

- ❖ Size of Throat & dosing tube and viscosity of reservoir liquid affect dosage significantly.
- ❖ Good agreement between measured and theoretical values of dosage.

References:

1. Park, K.A., Effects of inlet shapes of critical venturi nozzles on discharge coefficients, Flow Meas. Instrum., 6(1), 15-19 (1995).
2. Baylar, A., Aydin, M.C., Unsal, M. and Ozkan, F., Numerical modeling of venturi flows for determining air injection rates using FLUENT V6.2, Mathematical and Computational Applications, 14(2) 97-108 (2009).
3. Lavante, E.v. and Banaszak, U., Numerical simulation of transitional effects in critical venturi nozzles, Proc. Of the 8th International Symposium on Experimental and Computational Aerothermodynamics of Internal Flows, Lyon, (2007).

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